RECOMMENDATION FOR A SAFER TREATMENT OF WHITE PHOSPHORUS BURNS

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Naval Medical Research Unit No. 2
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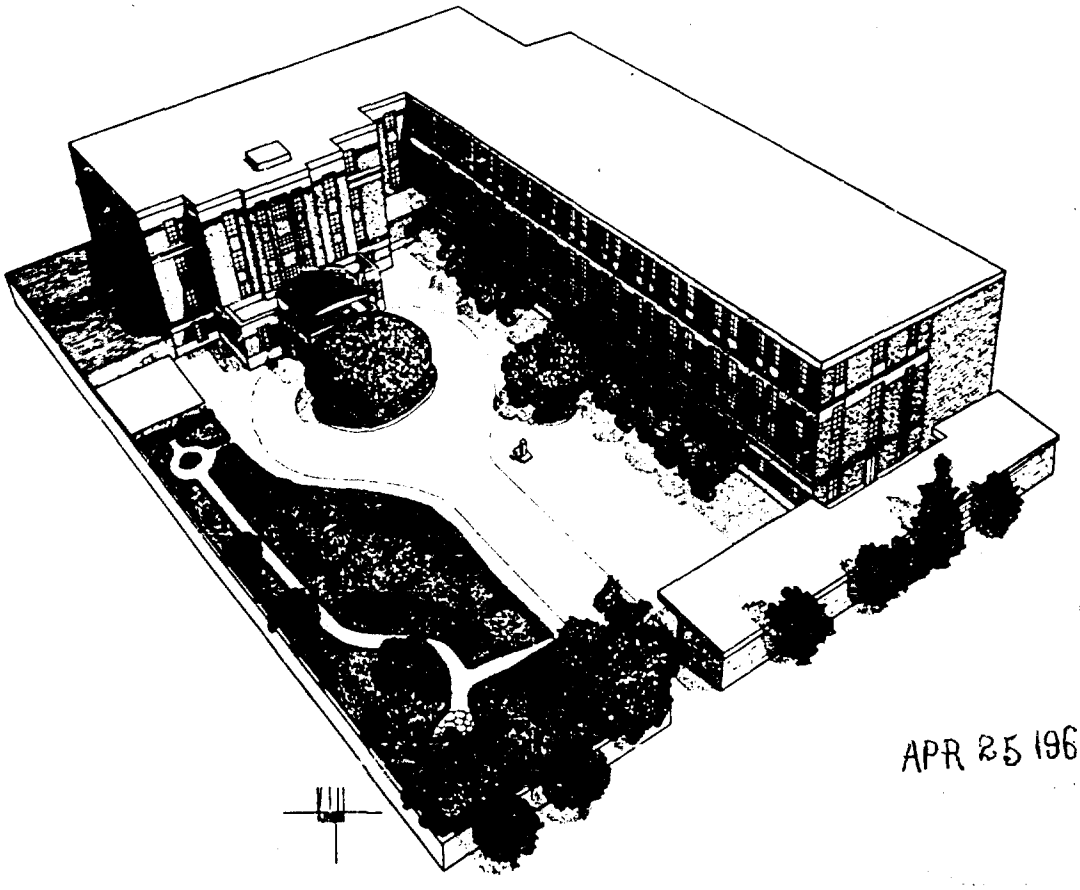

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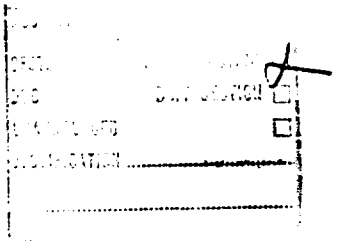

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RECOMMENDATION FOR A SAFER TREATMENT OF WHITE PHOSPHORUS BURNS

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ABSTRACT

One to three per cent solutions of copper sulfate have been used in the treatment of wound areas of casualties suffering white phosphorus burns. Excessive copper absorption with acute toxicity reportedly has occurred in some cases where such solutions have been left in contact with appreciable areas of open wound for extended intervals of time. Laboratory tests suggest that 0.05 per cent copper sulfate is equally effective. Field trials are recommended.

The use of copper sulfate solutions during the initial emergency removal of white phosphorus particles in victims of phosphorus shells and grenades has been reported to cause copper intoxication in some instances (1). Therefore, means must be found to avoid such unnecessary risks.

The rationale for the traditional use of copper sulfate along with debridement procedures to remove the embedded white phosphorus particles appears to be based primarily on the fact that copper sulfate inactivates the white phosphorus particles while at the same time making them more visible in the tissue. These effects are due to the chemical reaction between the copper ions and the mixture of oxidation products on the surface of the white phosphorus particle to produce a black insoluble layer covering the phosphorus surface. The covering markedly depresses further oxidation of the white phosphorus remaining in the center of the particles and renders the whole particle inert. The chemical nature of the black compound is uncertain; it may be cupric phosphide, Cu_3P_2.

Since the use of copper sulfate has been long accepted as a necessary and useful part of the debridement procedure it appeared worthwhile to attempt to modify its use in such a manner that the possible toxicity factor could be reduced while retaining its effectiveness. An obvious alternative approach would have been a search for other compounds to replace copper sulfate; however, in view of the promising preliminary results described below this was not undertaken.

Assuming that the relatively rapid formation of an insoluble black coating on the white phosphorus particle was a suitable and satisfactory requirement for the copper sulfate solution in the phosphorus burn therapy, tests were run to determine the effects of copper sulfate concentration upon this action. Solutions containing 5, 1, 0.5, 0.1, 0.05, 0.025, and 0.01 per cent copper sulfate were tested with small, 2 to 3 mm diameter, pieces of white phosphorus. It was found that all concentrations of copper sulfate down to 0.025 per cent formed black deposits covering the phosphorus surface within approximately 3 minutes. Thus, in vitro, it was clear that lower concentrations of copper sulfate than those normally employed were equally effective.

Next, brief tests were made with white phosphorus particles partially embedded in muscle tissue of an anesthetized rabbit. The copper sulfate solutions were applied to the area with soaked gauze pads. The results indicated that the blackening effect was slow with 0.025 per cent copper sulfate but satisfactory with the 0.05 per cent concentration. Trials under actual treatment conditions are necessary to determine the final effective level.

From this preliminary study it appears that a simple reduction in concentration of copper sulfate to 0.05 per cent will allow continuation of the use of the solution in the treatment technique for white phosphorus burns while simultaneously reducing the hazards.

Among the numerous factors influencing the rate of diffusion of copper ion into the circulation from the treatment solution in an open wound area is the concentration of the copper ion in the solution covering the wound area; the diffusion rate is directly proportional to the concentration. Therefore, the twenty-fold reduction in concentration suggested by the present results should result in a twenty-fold reduction in copper absorbed per unit of exposure time and area and thereby virtually remove any danger of copper intoxication.

Under these altered circumstances such measures as prophylactic use of oral penicillamine or other sequestering agents to remove copper ion after treatment of white phosphorus burns would not appear to be necessary. Furthermore, if sufficient copper were absorbed during therapy to cause toxic manifestations, as, for example, in the current use of 1 to 5 per cent copper sulfate solutions, it appears unlikely that penicillamine would be sufficiently rapid in its rate of removal of the copper to reverse the acute effects. One gram of oral penicillamine removes only one or two milligrams of copper in a patient with Wilson's disease (2). It is difficult to estimate what amount of copper absorption through the damaged tissue would be required to produce the toxic manifestations but it appears reasonable to expect that 50 milligrams or more would be necessary. This estimate is based on the fact that the daily turnover of copper in the normal

adult, for example, is of the order of 2-4 milligrams (3). Rapid removal of 50 milligrams or more of copper probably can not be accomplished with the usual dosage levels of penicillamine. One case of copper intoxication following extensive copper sulfate debridement of burned skin areas was reported (4) in which penicillamine therapy was employed. The authors reported that the patient excreted several milligrams of copper in the first few days of oral penicillamine therapy and simultaneously showed clinical signs of improvement. Whether or not the removal of the few milligrams of copper was responsible for that improvement seems obscure.

At present it seems most important to encourage field trials of the dilute solutions of copper sulfate for debridement procedures and to actively discourage prolonged soaking of open wounds with the higher concentrations of copper sulfate now in use.

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Background information concerning the use of copper sulfate solutions in the present treatment of white phosphorus burns was obtained from discussions with Cdr. C. E. Brodine, MC, USN, Director, Clinical Investigation Department, NMRI. Useful discussions of various phases of the problem were held with Captain R. H. Watten, MC, USN, Cdr. G. S. Huber, MSC, USN, Cdr. G. T. Strickland, MC, USN, and Lcdr. R. A. Gutman, MC, USNR, of NAMRU-2. Views concerning possible approaches to the problem were exchanged with Dr. Sorell L. Schwartz, Head, Pharmacology Division, NMRI.

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